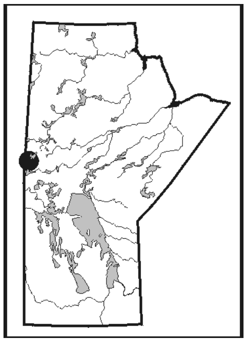
GS-5 PALEOMAGNETIC DATA FROM THE BIG ISLAND GNEISS DOME AT KISSISSING LAKE (NTS 63N/3)



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SUMMARY

Paleomagnetic data for the Big Island gneiss dome at Kississing Lake in the Kisseynew Domain are reported. The specimens have an extremely wide range of natural remanent magnetization intensities, large viscous remanence components, and well-defined, but scattered, characteristic remanence directions that suggest either mixed primary and secondary metamorphic origins and/or unrecognized post-remanence tectonic deformation.

INTRODUCTION

Over the past several years LITHOPROBE has sponsored a series of paleomagnetic studies on ~18 rock units in the Trans-Hudson Orogen (THO) of Manitoba and Saskatchewan (Fig. GS-5-1). Results have been reported to date on a dozen of these units, all in the ~ 1860 to ~ 1830 Ma age range, from five domains in the THO. These results have been recently summarized (Symons and Mackay, 1998). Here we report the first results from metamorphic rocks in the Kisseynew Domain, where peak metamorphism was reached between ~ 1820 and ~ 1805 Ma (Ansdell et al., 1995).

Paleomagnetists traditionally avoid metamorphic rocks because they typically have unresolvable remanence and structural complexities. The remanence often incorporates multiple components that are acquired during primary plutonism or deposition, and during subsequent metamorphism that both creates new magnetic minerals and re-aligns magnetic domains in the existing magnetic minerals during heating and subsequent cooling. Structural complexities arise because paleohorizontal is not easily determined. Thus the characteristic remanent magnetization (ChRM) of individual sites, or of the unit as a whole, may be scattered or deflected from the true direction. In general, only high-grade granulite-facies metamorphic rocks routinely give useful results as shown previously in the THO (Gala et al., 1998; Halls, 1998) and elsewhere (Constanzo-Alvarez and Dunlop, 1988; Symons and Vandall, 1990). In high grade terrains the rock is essentially entirely reconstituted into new minerals, eliminating all magnetic components except for peak metamorphism. In lower grade rocks the chances of success are correspondingly lower. Structural control is also tenuous at best. The concept used here is to look for a symmetrical domal structure in which a definable mafic layer can be tilt-corrected to possibly represent originally horizontal strata. This method has been used successfully for the Sahli charnockite in the Hanson Lake block and for the Wapisu gneiss dome in the northern Kisseynew Domain of the THO (Gala et al., 1998; Symons and Harris, in prep.). Unfortunately the paleomagnetic results for the Big Island gneiss dome are inconclusive either because of the presence of multiple remanence components or because of unrecognized structural complexities. Therefore this report provides the methods and the data in anticipation that the results might ultimately be usefully interpreted.

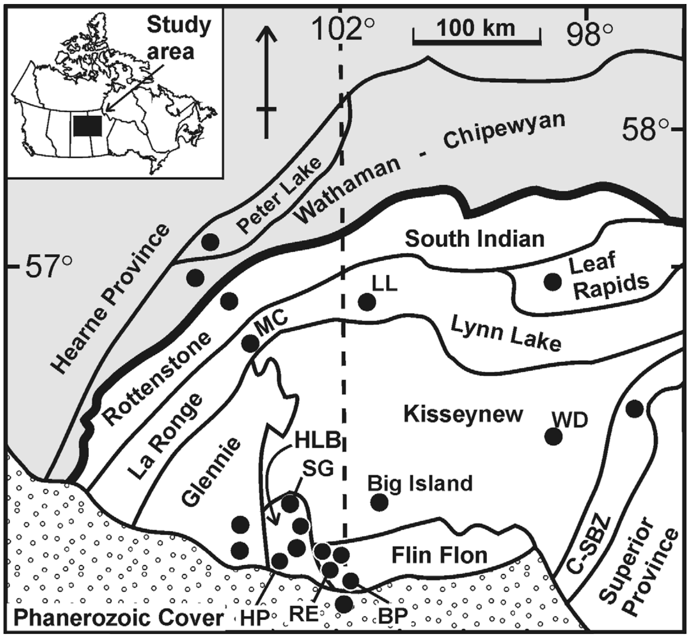

Figure GS-5-1: Tectonic elements of the Trans-Hudson Orogen and location of the Big Island gneiss dome. C - SBZ - Churchill - Superior Boundary zone; HLB - Hanson Lake block. Dots show paleomagnetic collection locations with those referred to in the text labelled: BP - Boot-Phantom plutonic complex; HP- Hanson Lake pluton; LL - Lynn Lake gabbro pipes; MC- Macoun Lake pluton; RE - Reynard Lake pluton; SG - Sahli granulite; WD - Wapisu gneiss dome.

GEOLOGY

The Big Island gneiss dome is located in the southern flank of the Kisseynew Domain (Fig. GS-5-2; Ansdell et al., 1995). The dome has been mapped at a scale of 1:63 360 in part by Bateman and Harrison (1943) and in part by Frarey (1948). It has recently been remapped by Schledewitz (1987) at 1:20 000. The dome has a core of foliated monzogranite and a mantle of supracrustal rocks. The gneisses that were sampled around the dome include garnet-graphite-biotite metatexites that possibly may belong to the Burntwood Group. Sediments of the Missi Group were deposited regionally on the Burntwood Group and now are represented by biotite gneisses. The biotite gneisses range from light to dark grey with magnetite, hornblende and biotite ranging up to 50% in variable proportions. The amphibolites that were sampled are probably older than the Missi and are layered, medium grained and garnetiferous with white plagioclase-quartz *lits* and veins.

The Burntwood and Missi groups are believed to have been originally deposited as turbidites and continental sandstones with minor interbedded volcanic rocks between ~1855 and ~1842 Ma from U/Pb dating of detrital zircons (Zwanzig, 1990, 1994, 1997; Ansdell, 1993; Ansdell et al., 1995; Machado and Zwanzig, 1995; David et al., 1996). Prior to peak metamorphism, these gneisses were intruded by grey medium- to coarse-grained magnetite-biotite-monzogranite with minor amounts of hornblende-biotite-granodiorite and such a body may form the core of the dome. Plutons of this composition that were emplaced elsewhere have yielded ages between ~1840 and ~1830 Ma (Ansdell et al., 1995). Alternatively Zwanzig et al. (1995) considered that some plutons of similar composition represent pre-Missi basement in the study area.

The gneisses and plutons were deformed beginning ~1840 Ma and peak deformation and metamorphism occurred between ~1820 and ~1805 Ma (Gordon et al., 1990; Ashton et al., 1992; Ansdell and Norman, 1995; David et al., 1996). More specifically the age of metamorphism along the southern flank of the Kisseynew Domain is relatively well constrained by U/Pb dating on zircon, monazite and titanite even though there are relatively few ages. The youngest pre-metamorphic

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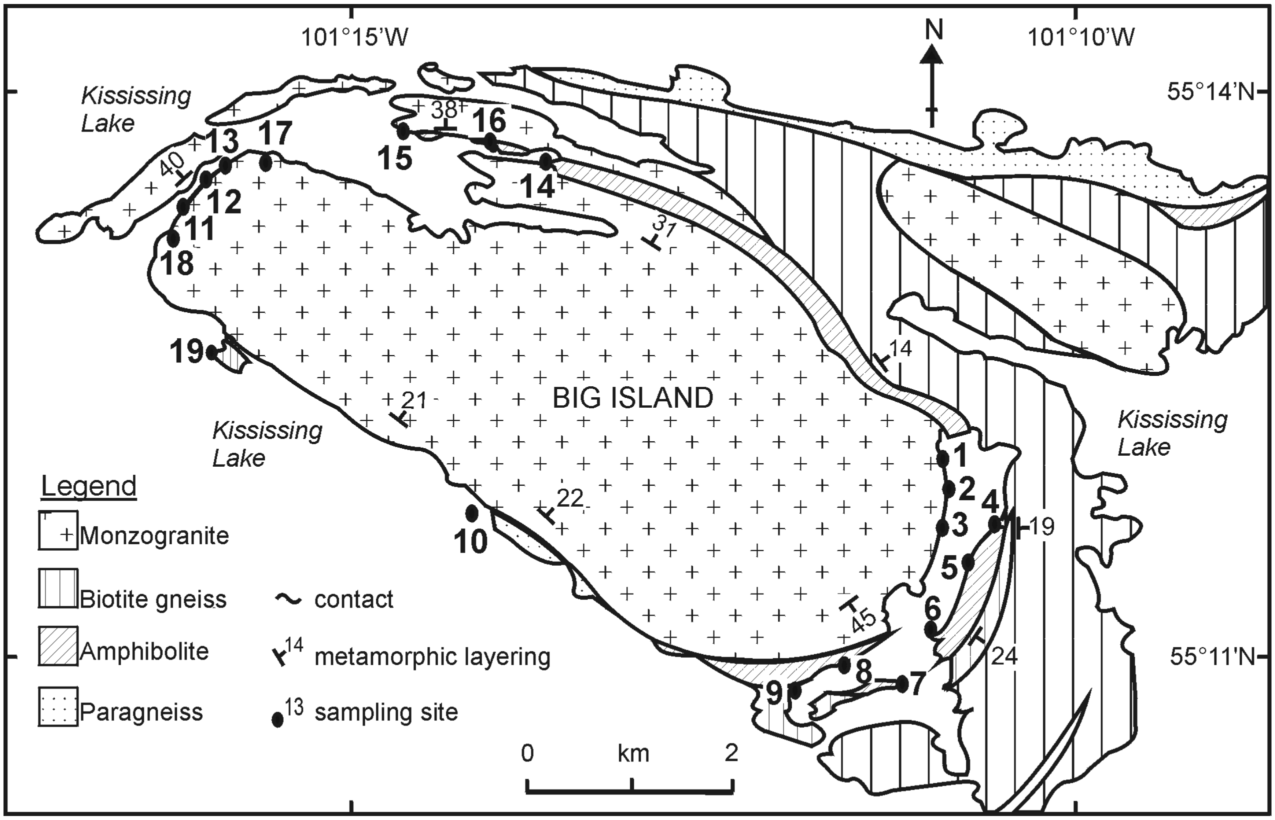

Figure GS-5-2: Geology of the Big Island gneiss dome simplified from Schledewitz (1987) with locations of sampling sites.

plutons give 1830 to 1825 Ma ages; peak metamorphic migmatites and mobilizates give 1817 to 1808 Ma ages; cooling ages on a variety of rock types are 1806 to 1804 Ma; and, post-metamorphic pegmatites give 1801 to 1799 Ma ages (Hunt and Roddick, 1988; Gordon et al., 1990; Ashton et al., 1992; Hunt and Schledewitz, 1992; Ansdell and Norman, 1993). Comparing the thermal unblocking temperature spectra to the closure temperatures of the radiometric age dating systems indicates that the ChRM at Big Island should postdate ~1815 Ma and predate ~1800 Ma.

EXPERIMENTAL PROCEDURES

Five or six core samples were drilled and oriented in situ by sun compass at each of 19 sites in shoreline outcrops around the Big Island gneiss dome on Kississing Lake (Fig. GS-5-2). Of the 19 sites, 12 are in amphibolites, five are in granite gneiss, one is in garnet-biotite paragneiss and one is in biotite paragneiss (Table GS-5-1). Five to 13 specimens were cut from these cores per site to yield a total of 180 specimens. After storage for two months in a magnetically-shielded room, in which all the paleomagnetic analyses were done, the specimen's natural remanent magnetizations (NRM) were measured on an automated cryogenic magnetometer. Their NRM intensities are highly variable and range over three orders of magnitude at most sites, and over six orders of magnitude at several sites that are underlain by amphibolites and granites. The median NRM intensities are 2 x 10-2 and 5 x 10-1 A/m for the large populations of amphibolite and granite specimens, and 2 x 10-3 and 3 x 10-1 A/m for the single sites of paragneiss and biotite gneiss, respectively.

One pilot specimen from each site was thermally demagnetized in 13 steps to 585°C. They showed that magnetite or titanomagnetite is the main carrier of the stable remanence or ChRM with many being "knee-shaped" (Fig. GS-5-3c, d, e) and with many having distributed unblocking temperature spectra up to nearly 585°C (Fig. GS-5-3a, b). Four sites (#8-10, 17) showed evidence of pyrrhotite with preferential unblocking in the 250° to 325°C range (Fig. GS-5-3a).

A second pilot specimen was step demagnetized in an alternating field (AF) in 12 steps up to 110 mT. AF proved to isolate the ChRM as well as, or better than, thermal demagnetization (Fig. GS-5-4) and so the remaining specimens were AF demagnetized in five or six steps from 15 or 20 mT up to between 50 and 100 mT.

For several sites, additional AF steps were added up to 140 mT or additional thermal steps were added in the 275° to 325°C range to fully demagnetize the specimens. Saturation isothermal remanent magnetization (SIRM) tests were run on six specimens by pulse magnetizing them in 12 direct field steps up to 900 mT and then AF demagnetizing them in seven steps up to 100 mT. The fact that the specimens saturate by about 100 mT and demagnetize rapidly indicates that the remanence carriers are predominantly multidomain magnetite (Fig. GS-5-5). The specimen ChRM directions were isolated using orthogonal vector plots

Table GS-5-1
Site mean remanence data.

Site	Unit	Sampling n, n', e_n, e_r	Dec (°)	Inc (°)	α_{95} (°)	k
1	G	5, 8, 7, 1	15	29	17	11
2	G	5, 9, 8, 0	31	31	37	3 *
3	G	5, 5, 3, 3	40	45	27	7 *
4	A	5, 8, 6, 0	142	27	7	106
5	A	5, 10, 8, 0	136	24	5	107
6	A	5, 8, 6, 0	9	79	17	17
7	A	5, 10, 7, 0	112	31	6	117
8	A	5, 10, 9, 0	198	82	9	33
9	A	5, 11, 7, 2	134	39	15	13
10	B	5, 11, 8, 0	134	69	17	12
11	A	6, 11, 0, 0				
12	A	5, 10, 0, 0				
13	A	5, 11, 3, 6	269	47	23	6 *
14	A	5, 9, 0, 0				
15	A	5, 16, 16, 0	82	54	9	19
16	A	5, 8, 3, 3	75	36	24	9 *
17	G	5, 6, 5, 1	16	52	16	20
18	G	5, 11, 7, 2	96	84	14	15
19	P	5, 11, 8, 1	10	26	38	3 *

A = amphibolite, B = biotite gneiss, G = granite, P = paragneiss
n = number of cores, n' = number of specimens, e_n, e_r = number of normal and reverse end points used

* = unacceptable for averaging

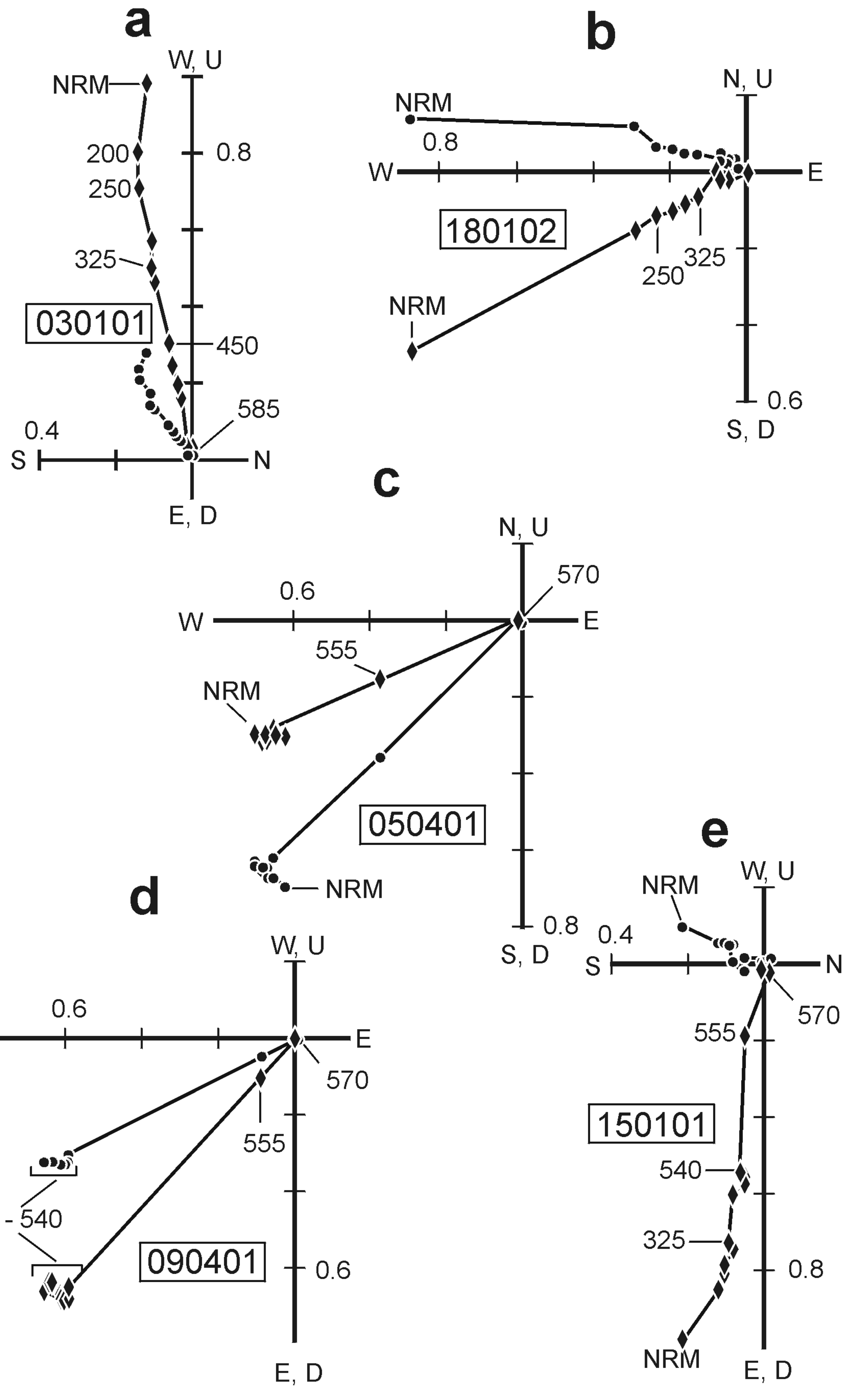

Figure GS-5-3: Orthogonal vector plots for several specimens from the Big Island gneiss dome. Steps are labelled in °C. Axial values expressed as a ratio of the NRM intensity. Circles are in the horizontal N, E, S, W plane and diamonds are in the vertical up (U), down (D) plane.

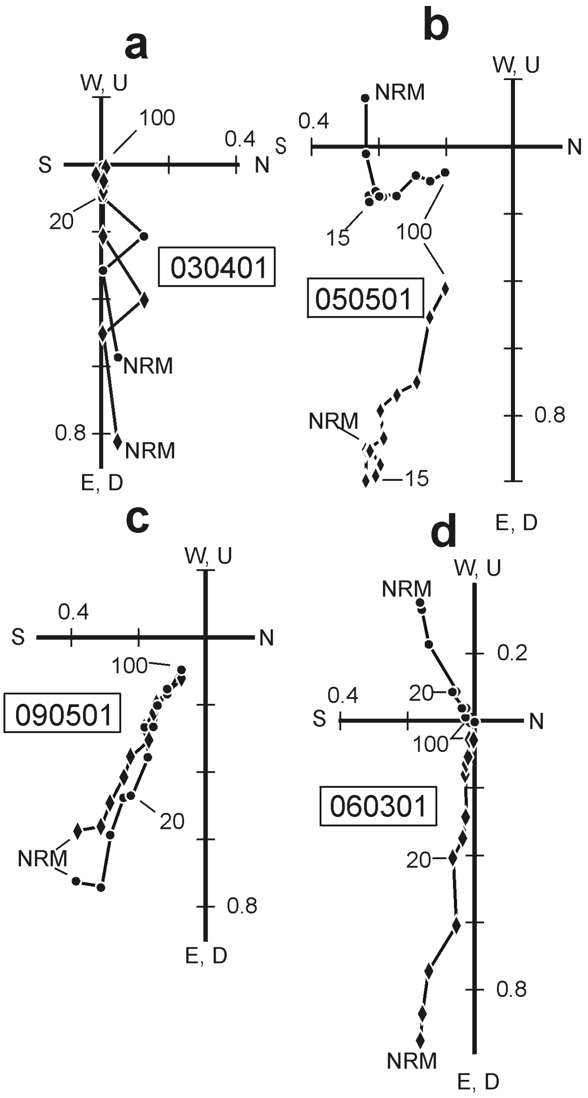

Figure GS-5-4: Orthogonal vector plots for specimens on AF demagnetization. Conventions as in Figure GS-5-3 except steps are labelled in mT.

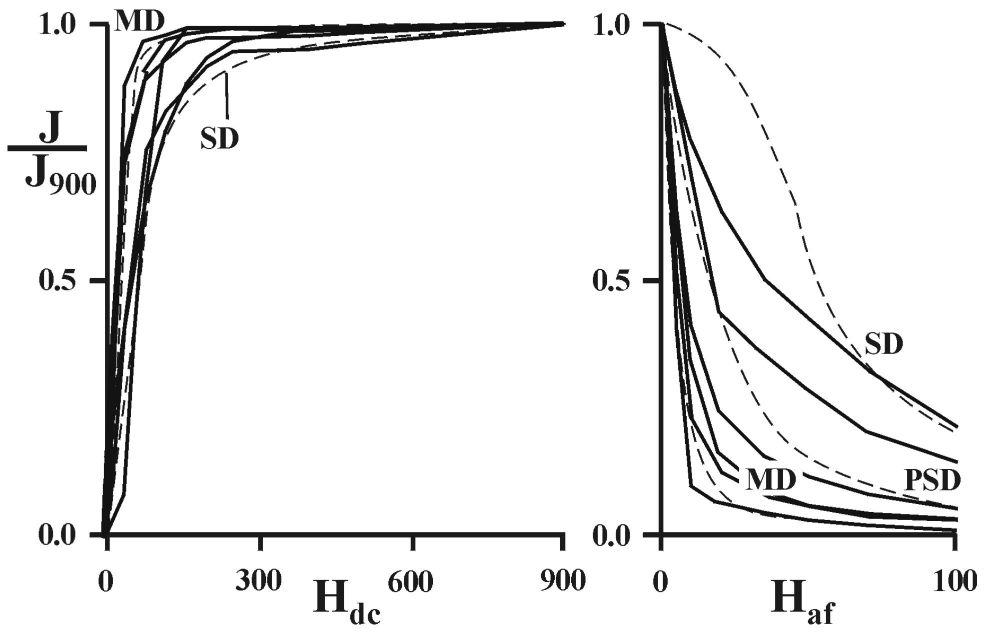

Figure GS-5-5: Remanence intensity acquisition and decay curves from saturation isothermal remanent magnetization testing. The field intensities, H_{dc} and H_{af}, axes are measured in mT. The dashed lines are reference curves for single domain (SD), pseudosingle (PSD) and multidomain (MD) magnetite.

(As and Zijderveld, 1958) and least squares fitting (Kirschvink, 1980) of the step directions. The site mean ChRM directions were obtained using Fisher (1953) statistics (Table GS-5-1).

DISCUSSION

The incoherent nature of the ChRM in the Big Island gneiss dome was very apparent when the NRMs were first measured and found to range over several orders of magnitude in intensity even after being stored in a field-free space for two months to allow their viscous remanent magnetization components to decay. Although ChRM end-points were relatively easily defined for most specimens, they proved to be very scattered in most sites. In three sites (#11, 12, 14; Table GS-5-1), these directions were randomly oriented. With the exclusion of up to two erratic directions, mean directions of loose clusters could be defined for a further five sites (#2, 3, 13, 16, 19). The remaining sites give "marginal" clusters by the standards of most paleomagnetic studies for six sites (#1, 6, 9, 10, 17, 18), leaving only five sites (#4, 5, 7, 8, 15) that give paleomagnetically "solid" mean directions.

When the site mean ChRM directions are plotted for the 11 "marginal" and "solid" sites, they too are widely scattered (Fig. GS-5-6) with an overall mean of declination (D) = 106°, inclination (I) = 59°, radius of

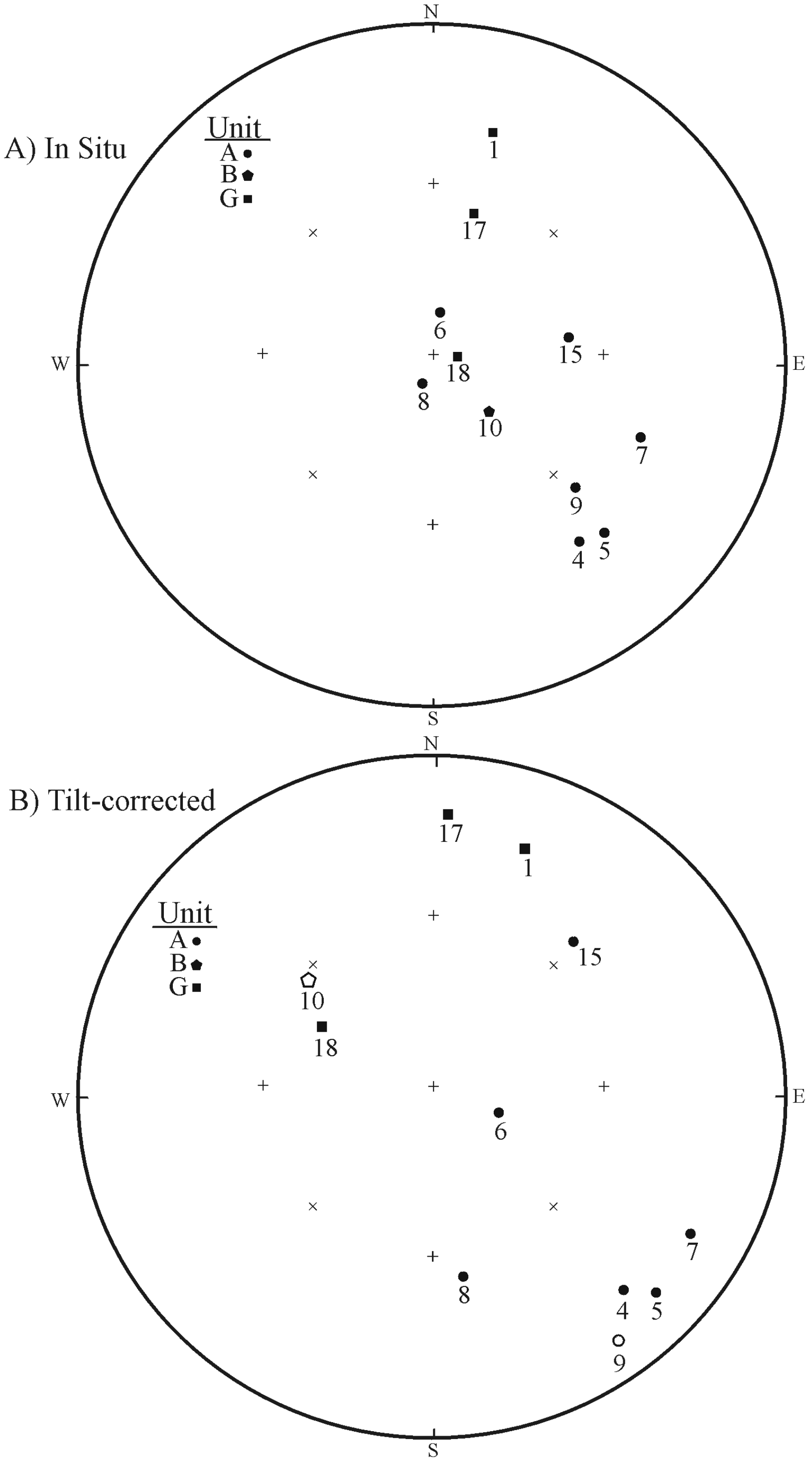

Figure. GS-5-6: Equal-area stereonets showing site mean ChRM directions for the Big Island gneiss dome. Site numbers and unit labels are from Table GS-5-1.

cone of 95% confidence (A95) = 22°, and precision parameter (k) = 5.2. After tectonic corrections using the mapped dip attitudes of the mafic layer, the mean becomes D = 98°, I = 47°, A95 = 58° and k = 1.6. Applying the tectonic correction does degrade the clustering significantly at the 95% confidence level. This confirms that the ChRM is substantially post-metamorphic. The data provide some evidence that residual pre-metamorphic components are present because the amphibolite sites show a distinct bias into the lower southeast quadrant and the granites, perhaps, into the lower northern hemisphere (Fig. GS-5-6a). A final point to be made is that the site mean ChRM directions, excluding sites 4 and 5, form a wide swath from southeast to near-vertical to north (Fig. GS-5-6a) that is similar to those directions found elsewhere in the THO, but are otherwise uninformative at present.

Thus the specimen data and site mean directions suggest that: a) the large viscous remanent magnetization components may not be entirely removed from all specimens; b) residual primary remanence may still be present in some specimens; c) most specimens have a significant secondary but possibly not an overriding remagnetization component that was acquired during metamorphism at ~1810 Ma; and, d) tectonic deformation of the dome both internally and in the surrounding area may be more complex than present mapping suggests, resulting in the need to apply tectonic corrections that are not presently evident.

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